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USNWS Notice, 18 Feb 1982

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(12)

AD B061070

NWSY TR 81-6

SUSCEPTIBILITY INDEX OF EXPLOSIVES TO ACCIDENTAL INITIATION

By
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Naval Explosives Development Engineering Department

October 1981

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(12)
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NWSY-TR-81-6	2. GOVT ACCESSION NO. AD-B061070L	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SUSCEPTIBILITY INDEX OF EXPLOSIVES TO ACCIDENTAL INITIATION		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert Petersen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Weapons Station Yorktown, VA 23691 (Code 50)		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NAVSEA Work Request N0002481WR01848 dtd 10 Apr 1981
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE October 1981
		13. NUMBER OF PAGES i-iv, 1-23 & A.1-A.2
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to U.S. Government agencies only; Test and Evaluation; October 1981. Other requests for this document must be referred to the Naval Weapons Station, Yorktown, VA 23691.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Explosives
Sensitivity
Susceptibility

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See reverse side of this form.

20. Assessing the hazard potentials of explosives has been an exceptionally difficult endeavor in the past due to the considerable controversies that abound in the area of sensitivity testing. Interpretation of the significance of the various test methods' results, conflicting results from apparently similar test methods, and even the definition of the word sensitivity are the frequent subjects of debate among the experts. As a result, very little useful information has filtered down to those who most need it - at the working level.

Of paramount concern to those working with or near explosives is their susceptibility to accidental initiation. A method for assessing that hazard by inference from sensitivity test results is described in this report. Sixty-two explosives are ranked in a Susceptibility Index (S.I.).

Additionally, attention is focused on a few aspects of test procedures and data reporting that has resulted in the publishing of erroneous and misleading information in the past.

F O R E W O R D

1. Of paramount concern to those working with or near explosives is their susceptibility to accidental initiation. A method for assessing that hazard by inference from sensitivity test results is described in this report. Sixty-two explosives are ranked in a Susceptibility Index (S.I.).

2. The effort reported herein was authorized and funded under the Naval Sea Systems Command (SEA-64E) Work Request N0002481WR01848 dated 10 April 1981.

Released by

W. McBride

W. McBRIDE, Director
Naval Explosives Development
Engineering Department
October 1981

Under authority of
JOHN F. FOX
Commanding Officer

TEST ABBREVIATIONS USED IN THIS REPORT

Tests conducted by the Naval Surface Weapons Center (formerly Naval Ordnance Laboratory (NOL)), White Oak Laboratory, Silver Spring, MD:

Test	Abbrev
Drop Hammer Impact	NOL Drop Hammer Impact
Large Scale Gap Test	NOL LSGT
Small Scale Gap Test	NOL SSGT

Tests conducted by the Los Alamos National Laboratory (LANL) (formerly Los Alamos Scientific Laboratory), Los Alamos, NM:

Test	Abbrev
Large Scale Gap Test	LANL LSGT
Small Scale Gap Test	LANL SSGT
Minimum Priming Charge	LANL Minimum Priming Charge
Wedge	LANL Wedge
Rifle Bullet	LANL Rifle Bullet
Drop Hammer Impact	LANL Drop Hammer Impact

Tests conducted by the Naval Surface Weapons Center (formerly Naval Weapons Laboratory (NWL)), Dahlgren Laboratory, Dahlgren, VA:

Test	Abbrev
Velocity-50% point SUSAN	NWL/D V-50 SUSAN
Lowest Violent Reaction SUSAN	NWL/D LVR SUSAN

Tests conducted by the Naval Explosives Development Engineering Department (NEDED), Naval Weapons Station, Yorktown, VA:

Test	Abbrev
Drop Hammer Impact	NEDED Drop Hammer Impact

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CONTENTS (contd)

SUSCEPTIBILITY INDEX
OF EXPLOSIVES TO ACCIDENTAL INITIATION

I. INTRODUCTION

Susceptibility to accidental initiation is of primary concern to everyone associated with the use of explosives. Unfortunately, this characteristic cannot be quantitatively defined at this time, and the prospects for ever doing so are not good. Susceptibility is affected by chemical and physical properties of an explosive, and a multitude of other factors such as geometry, confinement, density, particle size/shape/distribution, etc. When these are coupled with the numerous modes, and possible combinations of modes, of achieving initiation such as heat, friction, impact, shock, electrostatics, etc., and the undefined mechanisms whereby incident energies may be focused on "hot spots," it can readily be appreciated why quantitative methods for assessing susceptibility are not available.

Lacking quantitative evaluation techniques, one possible alternative is to composite the susceptibility characterization from pertinent available sensitivity test data in such as way that it represents a "consensus," as it were, of a given explosive's susceptibility to initiation.

There are numerous types of sensitivity tests; each quantifies the energetic stimuli necessary to achieve a prescribed violent explosive response to a particular initiation mode.

Interpretation of sensitivity test data with regard to relevancy in assessing susceptibility to accidental initiation is highly risky and often misleading. How can a gap test requiring not only initiation but a sustained high-order detonation, or a hammer impact test on explosive spread on a square of sandpaper, realistically be related to the minimal energetic stimuli necessary to cause initiation in a solid explosive charge? All sensitivity tests may be similarly questioned as to their pertinence in assessing the potential hazard of any particular explosive load when subjected to the spectrum of its expected service environment.

Compounding the difficulty in assessing the potential hazards of explosives (i.e., their susceptibility) from the results of sensitivity testing is the manner in which that data is presented - and misused. A typical recurring example of misused or biased data is to draw the conclusion that Explosive X, with a 50-millimeter (mm) gap test value, is less sensitive than Explosive Y with a value of 60 mm in that same test. Actually both explosives will have varying gap sensitivity values depending upon the density of the test sample. The assessment difficulties become more acute, even when using "unbiased" data, if the attempt to correlate is being made among different test methods. An example of such a problem would be an attempt to arrive at a reasonable relative susceptibility statement from the facts that Explosive X has a 50-mm gap test value, and Explosive Y a 50-milligram (mg) value in a minimum priming charge test, or 500 feet per second (f/s) in a bullet test. There are also occasions when reported sensitivity test data has not discriminated between the pressed and cast versions of the same composition, or the standard test procedure was altered and the data not annotated.

Small wonder that explosive sensitivity is such a controversial subject, difficult to define and almost impossible to communicate. Attempts to even rank explosives have not been satisfactory due to "reversals" in their behavior from one type test to another.

This effort has two major aims - the first, to alert those concerned with explosives to accept only "good" sensitivity data; and secondly, to offer a method that simplifies the interpretation of that data with respect to accidental initiations by converting test methods' results to a common unit of measure - a Susceptibility Index (S.I.).

II. EVALUATION PROCEDURE

It is also believed that the guidelines for presenting sensitivity data and the evaluation procedure described below are simple and easily comprehended.

(1) From data sources listed in Section V, readily accessible sensitivity test data was compiled from the following:

- NOL drop hammer impact, large and small scale gap tests;
- LANL large and small scale gap, minimum priming charge, wedge, rifle bullet and drop hammer impact tests;
- NWL/D velocity (50 percent reactions) and lowest violent reaction SUSAN tests; and
- NEDED drop hammer impact tests.

Test assemblies are shown in Figures 1 through 6.

(2) Due to the strong density influence, each of the solid charge tests data were plotted graphically (except for SUSAN tests where charge density was not provided). These graphs, Figures 7 through 13, not only illustrate the necessity for density-accountability when comparing sensitivity test results, but also demonstrate the repeatability or degree of control over test variables. Since the primary interest to most explosive users is in the relatively high density ranges typical of explosive loaded weapons, 98 percent theoretical maximum density (% TMD) was chosen as the base line for collecting representative data points for comparison.

(3) Previous attempts to order explosive sensitivity by their rank in each of the test methods is not a satisfactory method if only because the highly significant, relative sensitivities of the explosives are lost - how much more sensitive is No. 1 than No. 2? Secondly, all explosives would have to be run in all of the test methods so they could be ranked in each. An easier solution is to consider the following. Even though the correlation between any given test method result and susceptibility is debatable, there is a commonality of information provided by each of the test methods' results. Thus, regardless of the type units employed to express results, the range of each test methods' results imply varying degrees of potential hazard, or susceptibility. For example, 80 mm in a large scale gap test, or 15 centimeters (cm) in a drop hammer impact test are values that say "Beware" to all data evaluators, just as a 1500 mg minimum priming charge, or 9000 f/s bullet test value, imply "Reasonably Safe." If the above concept is generally acceptable, then each test methods' units can be converted to a common "apparent susceptibility scale" from 0 to 250, where 50 corresponds to "Beware," and 200 to "Reasonably Safe."

(4) Conversion equations to the common S.I. for each of the test methods studied were developed and are listed in Table I. Table II contains the "raw" data and beneath them their equivalent S.I. values. The explosives are ranked by their average S.I. value, and the common unit of measure readily permits comparison of various test method results.

Figure 14 graphically displays the ordering of some of the explosives along the S.I. scale, and the spread and overlap of test results.

The methods used to develop the conversion equations are described in the Appendix, however, it should be kept in mind that this is a qualitative evaluation and the only real criteria for those equations is that they produce reasonable results.

The degree of agreement between test methods in characterizing the explosives was determined by calculating correlation coefficients for the various combinations as shown in Table III.

Nominal compositions of other than mono-explosives are listed in the Appendix, Table A.I.

III. DISCUSSION OF RESULTS

It should be apparent from the graphs of TMD versus results for the solid charge test methods, Figures 7 through 13, that comparisons of explosive sensitivities in those tests are meaningless unless densities are accounted for, and secondly, that more data is needed to adequately define the density effect in some of the tests.

The conversion equations, Table I, reveal some apparent limitations on some of the test methods; the LANL SSGT is not useful for relatively insensitive explosives, and the minimum priming charge test is not definitive for very sensitive explosives.

The tabulated S.I. values, Table II, provide a viable means for ranking explosives on a comparable density basis, and without requiring that all explosives be tested in all of the methods. Additionally, the drastic differences in test response of the cast version of a composition versus the pressed version is readily apparent, as is the erratic behavior of Pentolite. DATB is not quite as insensitive as might have been expected. The cast plastic-bonded explosives generally appear relatively insensitive in gap tests (difficult to achieve a sustained detonation), but are quite sensitive in other tests - emphasizing how misleading attempting to characterize an explosive by just one type test method might be.

Knowledge of the degree of agreement between test methods is valuable in avoiding redundancy in the selection of methods to characterize an explosive.

IV. SUMMARY

The use of a common measuring scale, the S.I., has many advantages: communication is simplified; anomalous results are more readily apparent - triggering a questioning of the validity of the data, or an investigation of a real learning opportunity; and most importantly, explosives' hazard potential can be compared even though they might not have been identically tested. It is likely that a conversion equation could be developed for any quantified, good sensitivity test (one that reproducibly differentiates the response of various explosives to energetic stimuli), permitting direct comparison with other test method results.

There are several observations worth repeating:

(1) The density-sensitivity graphing of solid charge test results is essential to conveying that data in a useful form.

(2) The pressed solid test charges are more sensitive in those tests studied here, than the cast charges of the same composition - each type must be given a separate, distinct identity.

(3) Response in drop hammer impact (type 12 tooling) is overwhelmingly influenced by the most sensitive ingredient in an explosive mix and hence should not be expected to correlate well with most solid charge tests.

(4) Any deviation from a standard test procedure, i.e., impact on solid chunks vice powders, should be reported with the test result.

Finally, the concept of the S.I. is straightforward. It neither distorts test data, nor detracts from the purpose of the various test methods, but rather attempts to derive additional usable information from them in a form that is easily conveyed to a broader audience of those individuals most in need of the information.

V. DATA SOURCES

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(4) J.N. Ayres, L.J. Montesi, and R.J. Bauer, Small Scale Gap Test (SSGT) Data Compilation; 1959-1972 Volume I: Unclassified Explosives, Naval Ordnance Laboratory, White Oak, Silver Spring, MD, NOLTR-73-132, 23 Oct 1973.

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(6) NEDED Impact data, Explosives, Physics & Chemistry Division files, Naval Explosives Development Engineering Department, WPNSTA Yorktown, 1979.

(7) W.R. Hammer, Summary of Susan Explosive Sensitivity Tests Conducted at the Naval Weapons Laboratory between August 16, 1961 and March 26, 1970, NAVSWC Dahlgren Laboratory, Dahlgren VA, NWL TR-2837, Sep 1972.

TABLE I. EQUATIONS TO CONVERT TEST RESULT UNITS TO SUSCEPTIBILITY INDEX VALUES

$$\text{NOL LSGT, S.I.} = 236 - 2.77 \times [\text{gap (mm)}]$$

$$\text{NOL SSGT, S.I.} = 190 - 16.9 \times [\text{gap (mm)}]$$

$$\text{LANL LSGT, S.I.} = 267 - 3.4 \times [\text{gap (mm)}]$$

$$\text{LANL SSGT, S.I.} = 105 - 12.6 \times [\text{gap (mm)}]$$

$$\text{LANL Minimum Priming Charge, S.I.} = 2.8 \times \sqrt{\text{weight (mg)}} + 64$$

$$\text{LANL Wedge, S.I.} = 61.4 \times \sqrt{\text{thickness (mm)}} + 38$$

$$\text{LANL Rifle Bullet, S.I.} = 0.025 \times [\text{velocity (ft/sec)}] - 3$$

$$\text{NWL/D SUSAN V-50, S.I.} = 0.35 \times [\text{velocity (ft/sec)}] + 26$$

$$\text{NWL/D SUSAN LVR, S.I.} = 0.11 \times [\text{velocity (ft/sec)}] + 41$$

$$\text{NEDED Drop Hammer Impact, S.I.} = 25.4 \times \sqrt{[\text{height (cm)}]} - 71$$

$$\text{NOL Drop Hammer Impact, S.I.} = 14.9 \times \sqrt{[\text{height (cm)}]} - 20$$

$$\text{LANL Drop Hammer Impact, S.I.} = 17 \times \sqrt{[\text{height (cm)}]} - 32$$

TABLE II. SUSCEPTIBILITY INDEX VALUES

Rank	Explosive	Gap tests (mm) LSGT NOL	Gap tests (mm) LSGT LANL	Gap tests (mm) SSGT NOL	Gap tests (mm) SSGT LANL	Gap tests S.I. avg	Drop hammer impact tests (cm) NEDED	Drop hammer impact tests (cm) NOL	Drop hammer impact tests (cm) LANL	Drop hammer S.I. avg	Wedge test (mm) LANL	Min prim chg test (mg) LANL	Bullet test (f/s) LANL	SUSAN V-50 test (f/s) NWL/D	SUSAN LVR test (f/s) NWL/D	S.I. avg of all tests
			60	9.8	5.5		16		14							
1	PETN S.I.:		63	24	36	41	31		32	32						37
		67	69	9.8	3.2		21	27	35							
2	PENTOLITE (P) S.I.:	50	32	24	65	43	45	57	69	57						50
		67	61	7.4	4.8		22	24	28							
3	RDX S.I.:	50	60	65	45	55	48	53	58	53						54
		64														
4	DINA S.I.:	59				59										59
			61	7.4			19	28	32							
5	HMX S.I.:		60	65		63	40	59	64	54						59
		62		7.8												
6	TNETB S.I.:	64		58		61										61
				7.4												
7	COMP A-5 S.I.:			65		65										65
		52	54	7.4	3.7		26	40	37		0.26	2	2150			
8	TETRYL S.I.:	92	66	65	58	70	59	74	71	68	69	68	59			67
		63		6.3			25	33								
9	CH-6 S.I.:	61		84		73	55	66		61						67
		53	58		2.6			28	40		0.43	25	2700	70	100	
10	9404 S.I.:	89	70		72	77		59	76	68	79	78	70	51*	52*	68
		60						36								
11	EDNA S.I.:	70				70		69		69						70
		60					44	33								
12	CYCLOTOL (P) S.I.:	70				70	90	66		78						74
			55	6.2	2.7				46		0.30	15				
13	9407 S.I.:		80	85	71	79			83	83	72	75				77
			53		64				39			20				
14	9007 S.I.:		87		87	87			74	74		77				79
		67	66		1.2		21	27	35		1.40	72				
15	PENTOLITE (C) S.I.:	50	43		90	61	45	57	69	57	110	88				79
			54		2.1			40	36		0.51	60	3000	225	225	
16	9010 S.I.:		83		79	81		76	70	72	82	86	76	104*	66*	81
		48					29	22								
17	PBXN-6 S.I.:	103*				103	66	50		58						81
				6.3			40	45	41							
18	OCTOL (P) S.I.:			84		84	90	80	77	82						83
					1.9				49							
19	9501 S.I.:				81	81			87	87						84
							38	42						120	600	
20	PBXN-101 S.I.:						86	77		82				68*	127*	86
							41	39						150	500	
21	PBXN-102 S.I.:						92	73		83				79*	96*	86
		23					10	17							200	
22	PBXN-103 S.I.:	172*				172	9	41		25					63*	87

TABLE II. SUSCEPTIBILITY INDEX VALUES (contd)

Rank	Explosive		Gap tests (mm) LSGT NOL	LSGT LANL	SSGT NOL	SSGT LANL	S.I. avg	Drop hammer impact tests (cm) NEDED	NOL	LANL	S.I. avg	Wedge test (mm) LANL	Min prim chg test (mg) LANL	Bullet test (f/s) LANL	SUSAN V-50 test (f/s) NWL/D	SUSAN LVR test (f/s) NWL/D	S.I. avg of all tests
				51		0.8				52		0.57	77		160	390	
23	9205	S.I.:		94		95	95			91	91	84	89		82*	84*	87
			57		5.9			31	60	69							
24	COMP B (P)	S.I.:	78		90		84	70	95	109	91						88
						2.0		43									
25	DETASHEET	S.I.:				80*	80	96			96						88
				52		1.9				60		0.61	55				
26	9011	S.I.:		90		81	86			100	100	86	85				89
					5.9												
27	TNB	S.I.:			90		90										90
					5.0			33	40								
28	PBXN-5	S.I.:			106		106	75	74		75						91
			48					34	48								
29	COMP C-4	S.I.:	103				103	77	83		80						92
				51		0.6		40	45	41		1.43	288	3800	190	300	
30	OCTOL (C)	S.I.:		94		97	96	90	80	77	82	112	112	92	93*	74*	94
			28					14	19								
31	PBXN-105	S.I.:	158*				158	24	45		35						97
			40					36	28								
32	PBXC-117	S.I.:	125*				125	81	59		70						98
			55	53		1.4				60		0.83	240	3300	200	850	
33	COMP B-3 (C)	S.I.:	84	87		87	86			100	100	94	107	82	96*	135*	100
			46	46		0.5		40	33	47		1.54	780	4200	210	210	
34	CYCLOTOL (C)	S.I.:	109*	111		99	106	90	66	85	80	114	142	100	100*	64*	101
			58	55		0.7		46	80	81		0.56	51	3200	295	890	
35	COMP A-3	S.I.:	75	80		96	84	101	113	121	112	84	84	80	129*	139*	102
			39					42	43						250	420	
36	PBXW-108	S.I.:	128*				128	94	78		86				114*	87*	104
			56	52		0.6		44	60	69		1.45	610		180	700	
37	COMP B (C)	S.I.:	81	90		97	89	97	95	109	100	112	133		79*	118*	105
			35					37	30								
38	PBXC-116	S.I.:	139*				139	84	62		73						106
			29					38	33							435	
39	PBXW-109	S.I.:	156*				156	86	66		76					89*	107
			45			0.6		39	43						350	600	
40	PBXN-106	S.I.:	111*			97*	104	88	78		83				149*	107*	111
					4.0												
41	PICRAMIDE	S.I.:			122		122										122
			26					78	118						170	465	
42	MINOL II	S.I.:	164				164	153	142		148				86*	92*	123
			48					86	95								
43	H-6 (P)	S.I.:	103				103	165	125		145						124
					4.4			87	100						300	620	
44	PBXN-3	S.I.:			116		116	166	129		148				131*	109*	126

TABLE II. SUSCEPTIBILITY INDEX VALUES (contd)

Rank	Explosive		Gap tests (mm)					Drop hammer impact tests (cm)				Wedge test (mm)	Min prim chg test (mg)	Bullet test (f/s)	SUSAN V-50 test (f/s)	SUSAN LVR test (f/s)	S.I. avg of all tests
			LSGT		SSGT		S.I. avg				S.I. avg						
			NOL	LANL	NOL	LANL		NEDED	NOL	LANL		LANL	LANL	LANL	NWL/D	NWL/D	
45	TNT (P)		46	50	5.7	0.4		94	210	148		2.00	375	4700			
		S.I.:	109	97	94	100	100	175	196	175	182	125	118	110			127
46	DIPAM				5.2				185	85							
		S.I.:			102		102		183	125	154						128
47	HBX-1		39					89	92								
		S.I.:	128*				128	169	123		146						137
48	DATB		27	42	3.0	0.3		>320	>320	>320		0.57	56				
		S.I.:	161	124	139	101	131	250	250	250	250	84	85				138
49	H-6 (C)		45	47	3.3			86	95						400	865	
		S.I.:	111	107	134		117	165	125		145				165*	136*	141
50	TRITONAL (P)		43					128	100								
		S.I.:	117				117	216	129		173						145
51	TRITONAL (C)		24	24				128	100						245	800	
		S.I.:	170	185			178	216	129		173				112*	129*	148
52	HBX-3		37					109	153								
		S.I.:	134				134	194	164		179						151
53	AN/TNT/AL 40/40/20		28														
		S.I.:	158				158										158
54	XPL D (P)		37	42				108	235	136					400	990	
		S.I.:	134	124			129	193	208	166	189				166*	150*	159
55	TNT (C)		30	27				94	210	148					425	1220	
		S.I.:	153	175			164	175	196	175	182				175*	175*	174
56	DESTEX		20	31												1255	
		S.I.:	181	162			172									179*	176
57	PICRATOL		37					212									
		S.I.:	134*				134	250			250						192
58	DNT		13														
		S.I.:	194				194										194
59	PBXN-4		33		3.0			>320	>320								
		S.I.:	145		139		142	250	250		250						196
60	DNB		3														
		S.I.:	228				228										228
61	TATB		10	18	1.0			>320	>320	>320			>15,300				
		S.I.:	208	206	173		196	250	250	250	250		250				232
62	NQ		0	8				>320	>320	>320							
		S.I.:	236	240			238	250	250	250	250						244

(C) Cast
(P) Pressed
* Density not reported
Test unit values

TABLE III. CALCULATED CORRELATION COEFFICIENTS

Test method	Correlation coefficient r_{xy}
COMPARED TO AVG GAP TEST:	
NOL LSGT	.986
LANL LSGT	.979
NOL SSGT	.963
LANL Bullet	.933
Drop Hammer Impact (mono explosives)	.895
LANL SSGT	.838
LANL Minimum Priming Charge	.685
Avg Drop Hammer Impact	.557
NWL/D SUSAN V-50	.430
LANL Wedge	.264
NWL/D SUSAN LVR	.175
COMPARED TO AVG DROP HAMMER IMPACT TEST:	
LANL Drop Hammer Impact	.988
NOL Drop Hammer Impact	.979
NEDED Drop Hammer Impact	.977
NWL/D SUSAN LVR	.728
LANL Bullet	.709
NWL/D SUSAN V-50	.648
LANL Minimum Priming Charge	.254
LANL Wedge	.157
COMPARED TO SUSAN LVR TEST:	
NWL/D SUSAN V-50	.700

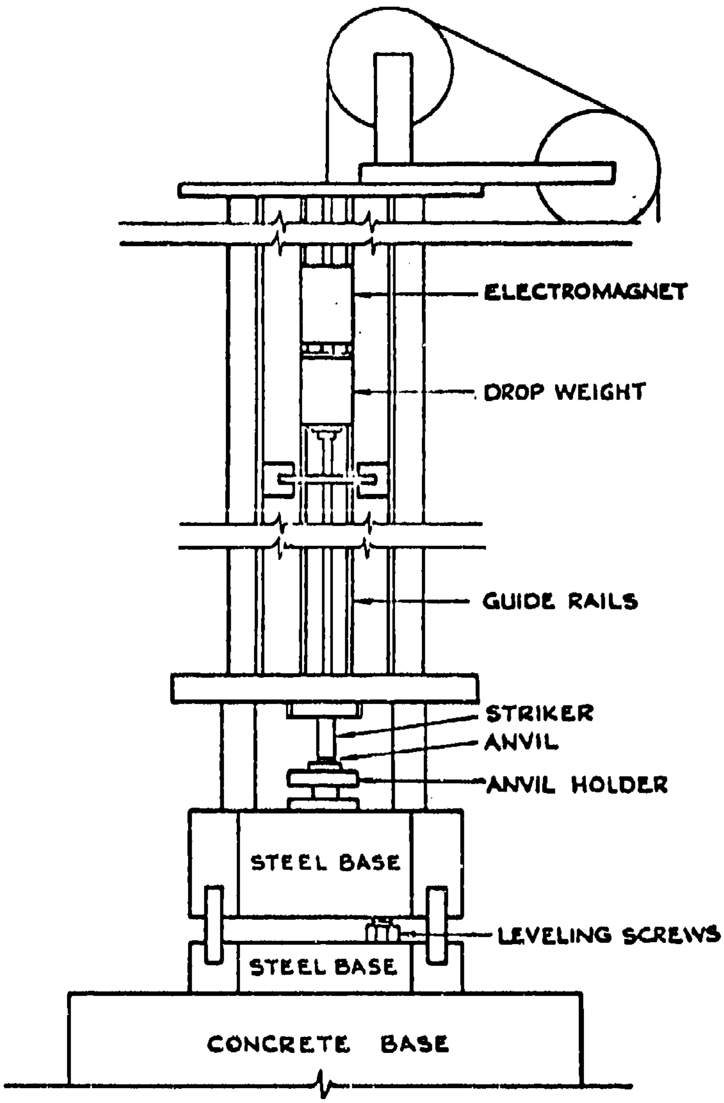


FIGURE 1. DROP WEIGHT IMPACT MACHINE
(ERL MODEL, TYPE 12 TOOLS)

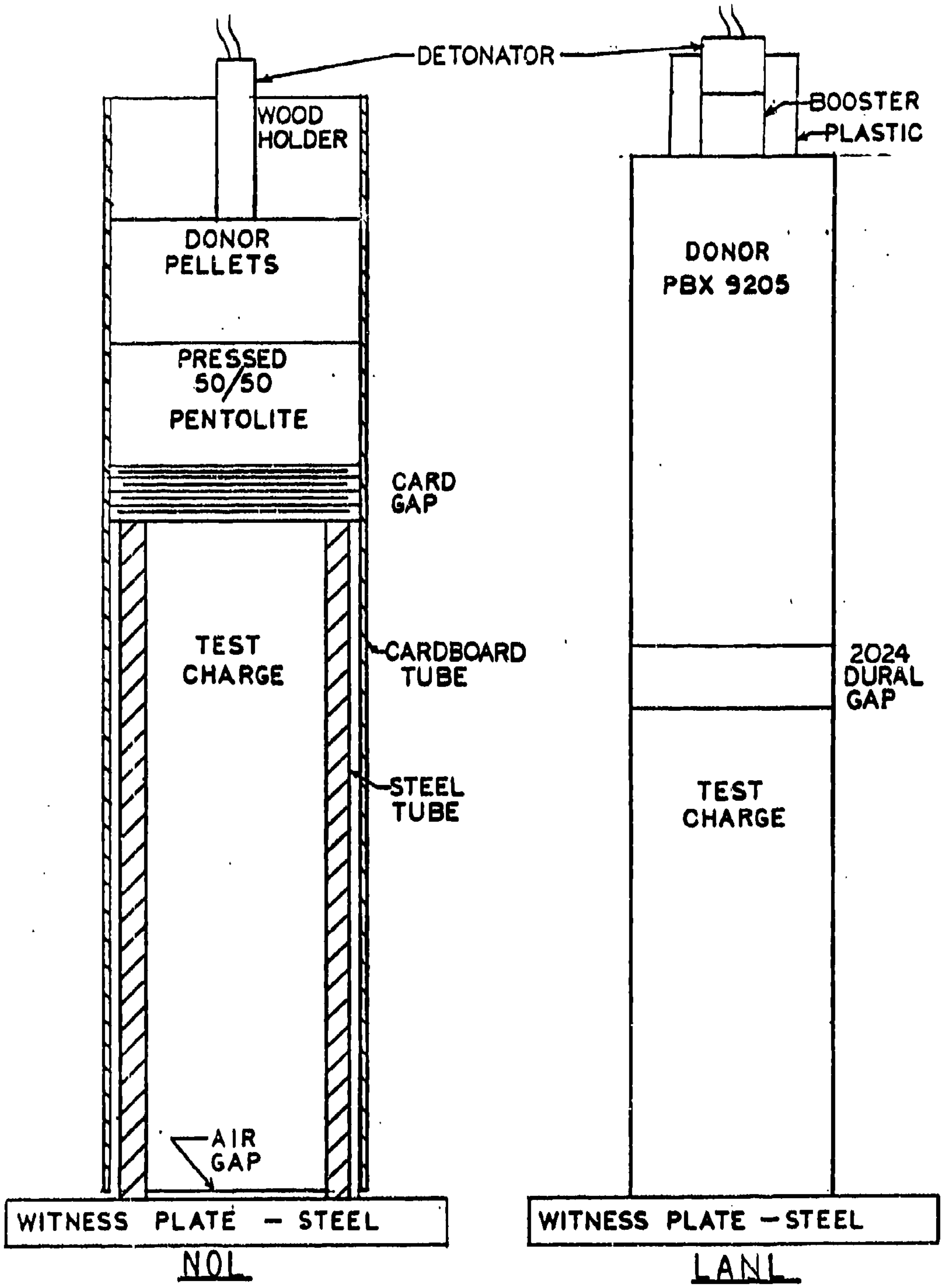


FIGURE 2. LARGE SCALE GAP TEST ASSEMBLY

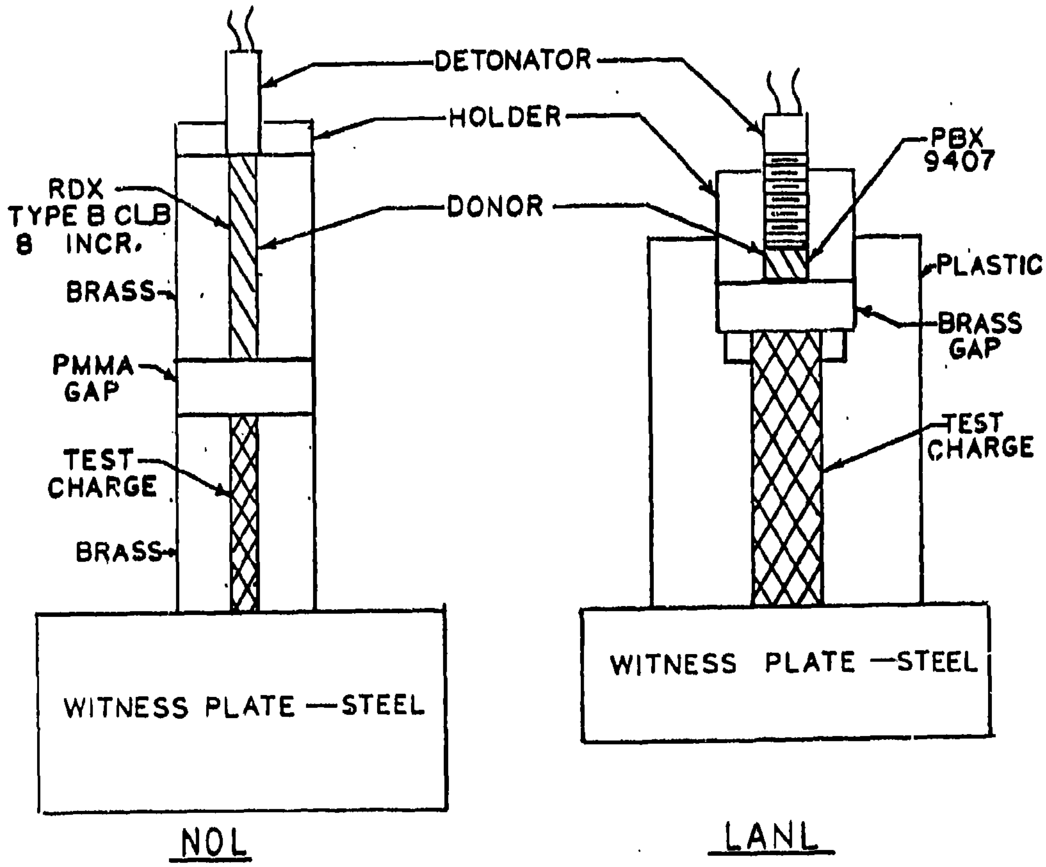
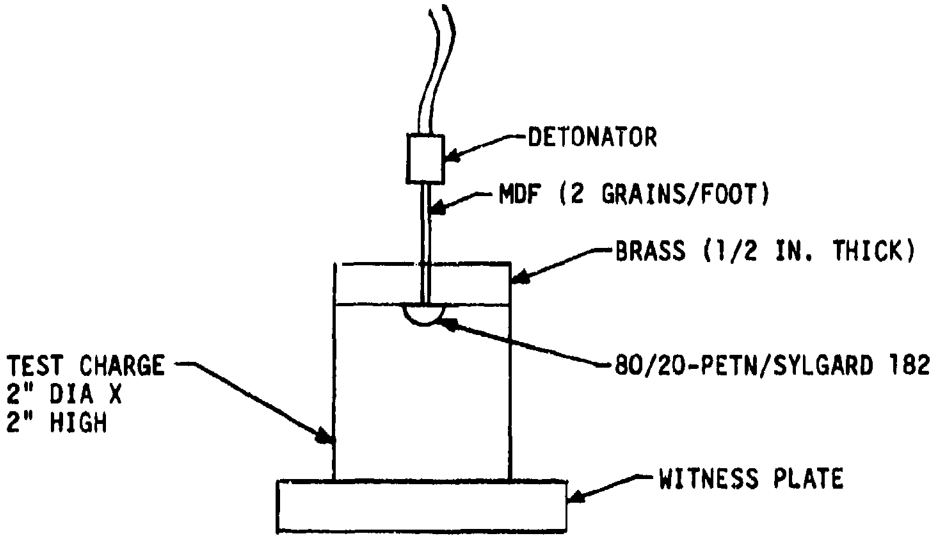
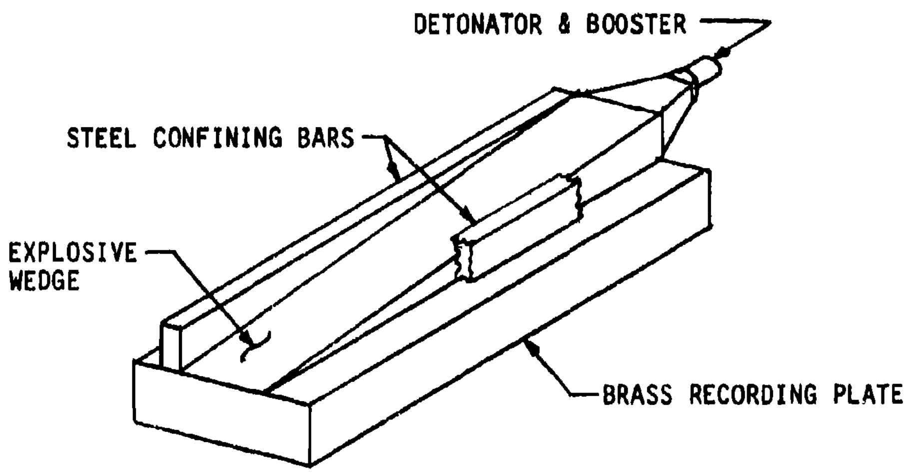


FIGURE 3. SMALL SCALE GAP TEST ASSEMBLY

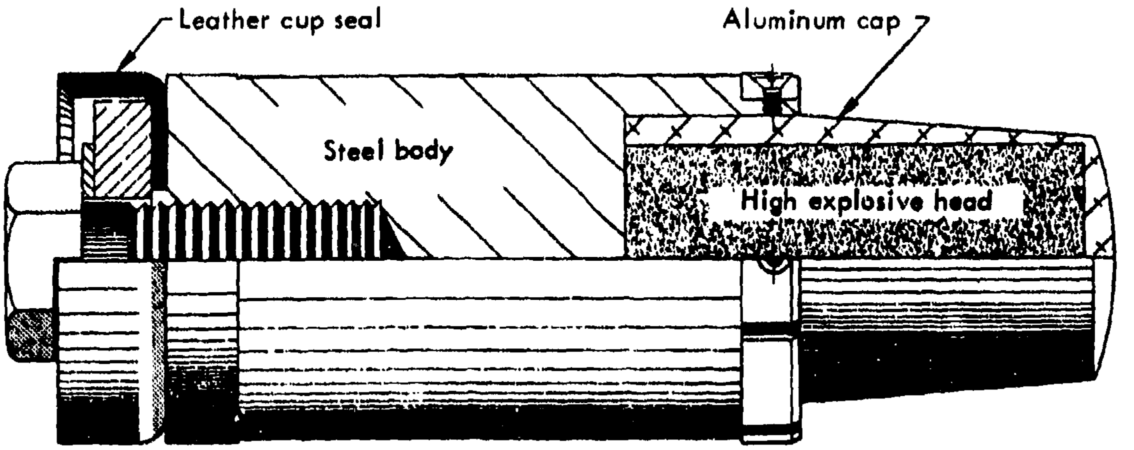


MINIMUM PRIMING CHARGE TEST



WEDGE TEST

FIGURE 4. MINIMUM PRIMING CHARGE AND WEDGE TEST ASSEMBLIES



SUSAN PROJECTILE

V-50: PROJECTILE IMPACT VELOCITY AGAINST STEEL PLATE WHERE A VISIBLE EXPLOSIVE REACTION OCCURS.

LVR: LOWEST IMPACT VELOCITY WHERE A VIOLENT EXPLOSIVE REACTION OCCURS, AS EVIDENCED BY OVERPRESSURE 10 FEET FROM IMPACT SITE.

FIGURE 5. SUSAN TESTS

RIFLE BULLET: LOWEST IMPACT VELOCITY OF STEEL CYLINDER (APPROX. 0.3 INCH DIA BY 0.5 INCH LONG), FIRED FROM .30 CALIBER RIFLE INTO ONE END OF A BARE CYLINDRICAL EXPLOSIVE CHARGE (2 INCHES DIA BY 3 INCHES LONG), RESULTING IN A PRESCRIBED OVERPRESSURE RISE NEAR IMPACT SITE.

FIGURE 6. RIFLE BULLET TEST

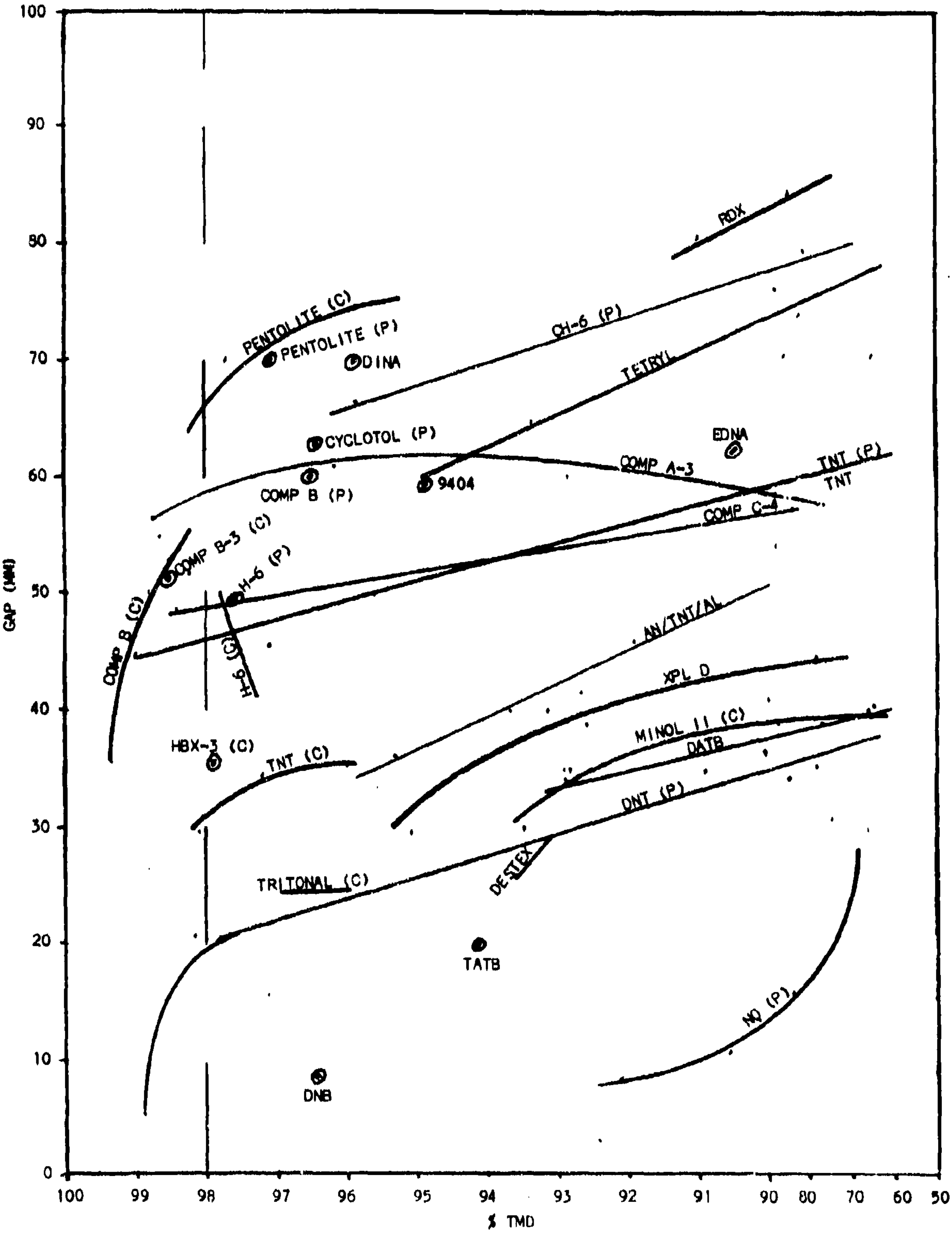


FIGURE 7. NOL LARGE SCALE GAP TEST

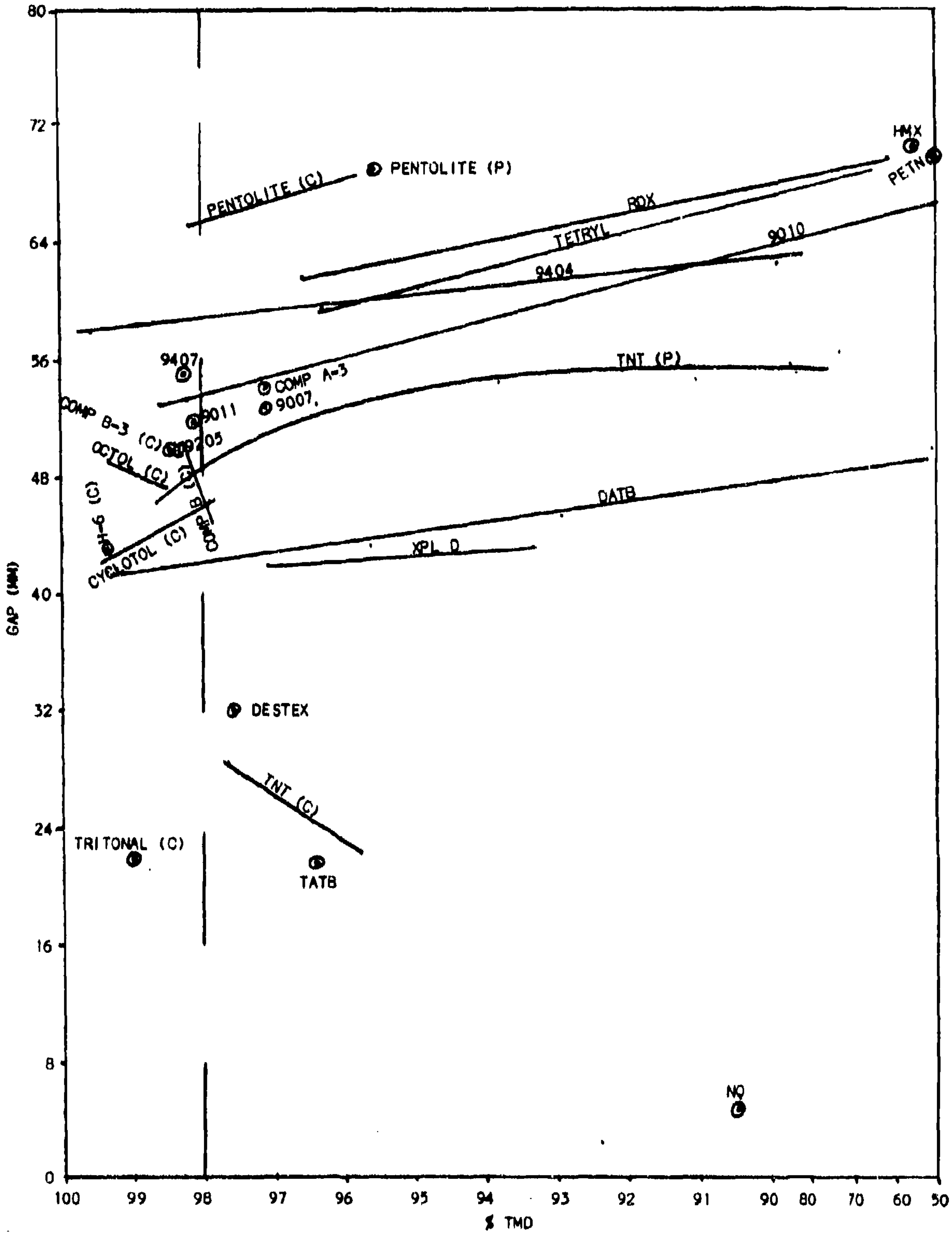


FIGURE 8. LANL LARGE SCALE GAP TEST

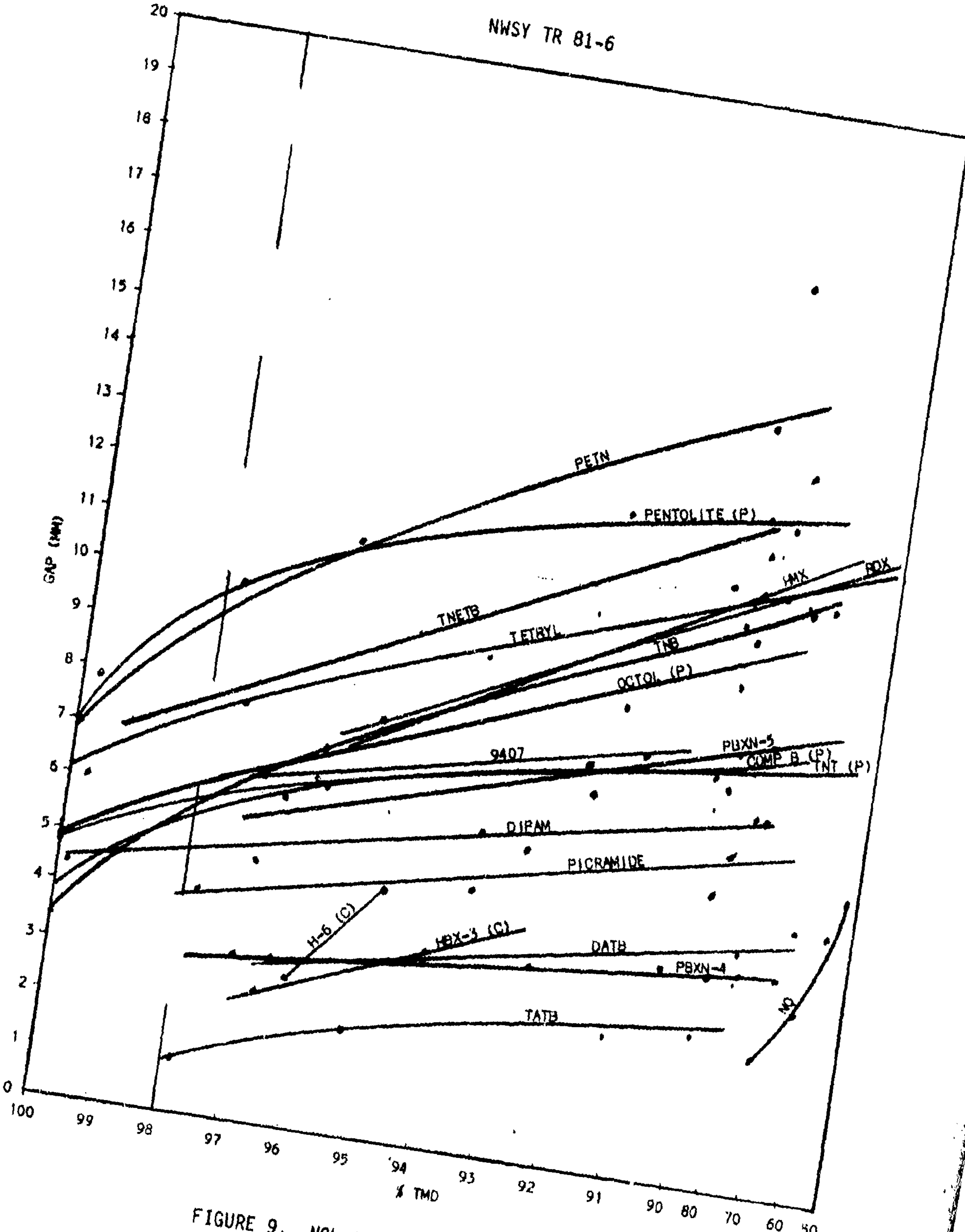


FIGURE 9. NOL SMALL SCALE GAP TEST

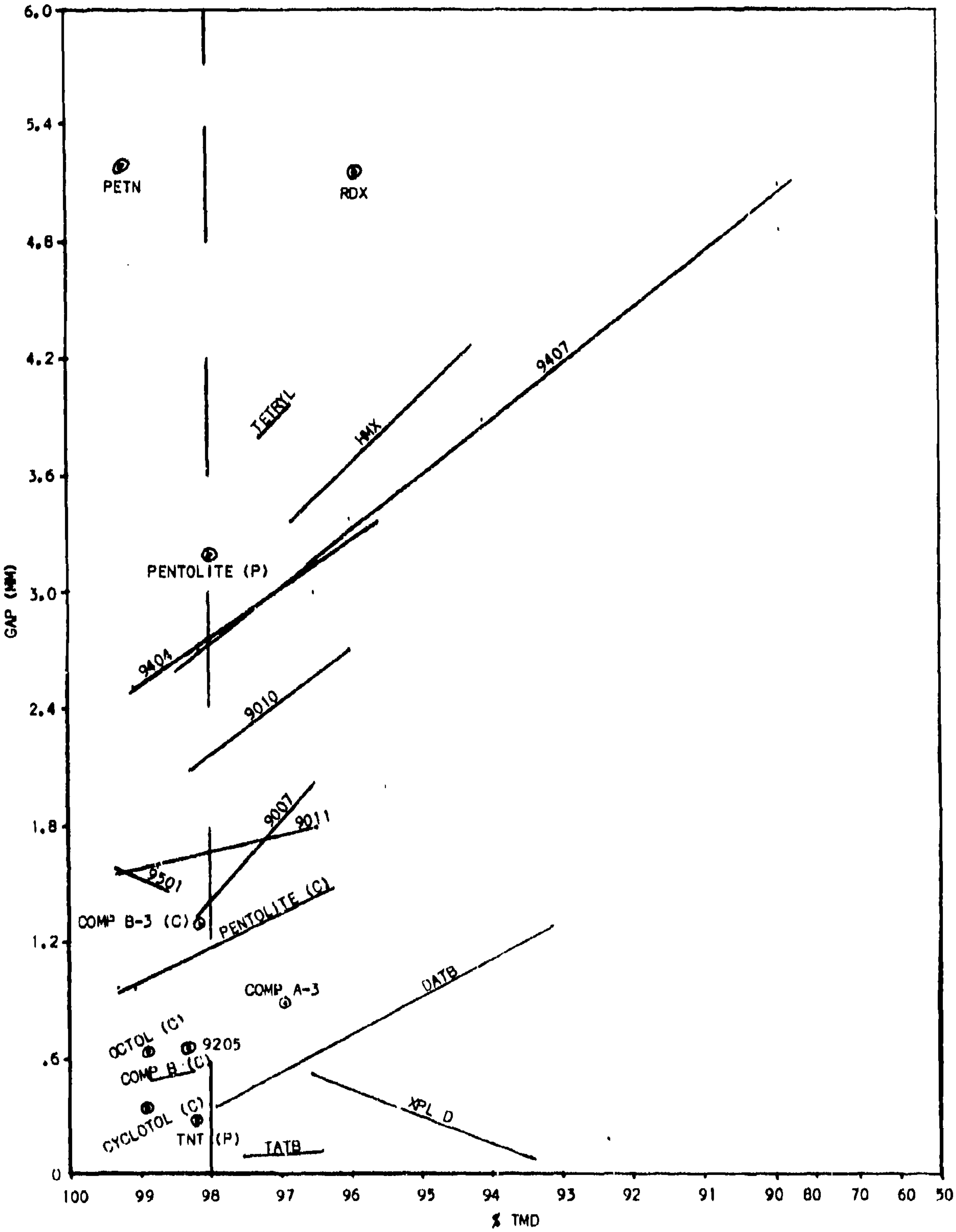


FIGURE 10. LANL SMALL SCALE GAP TEST

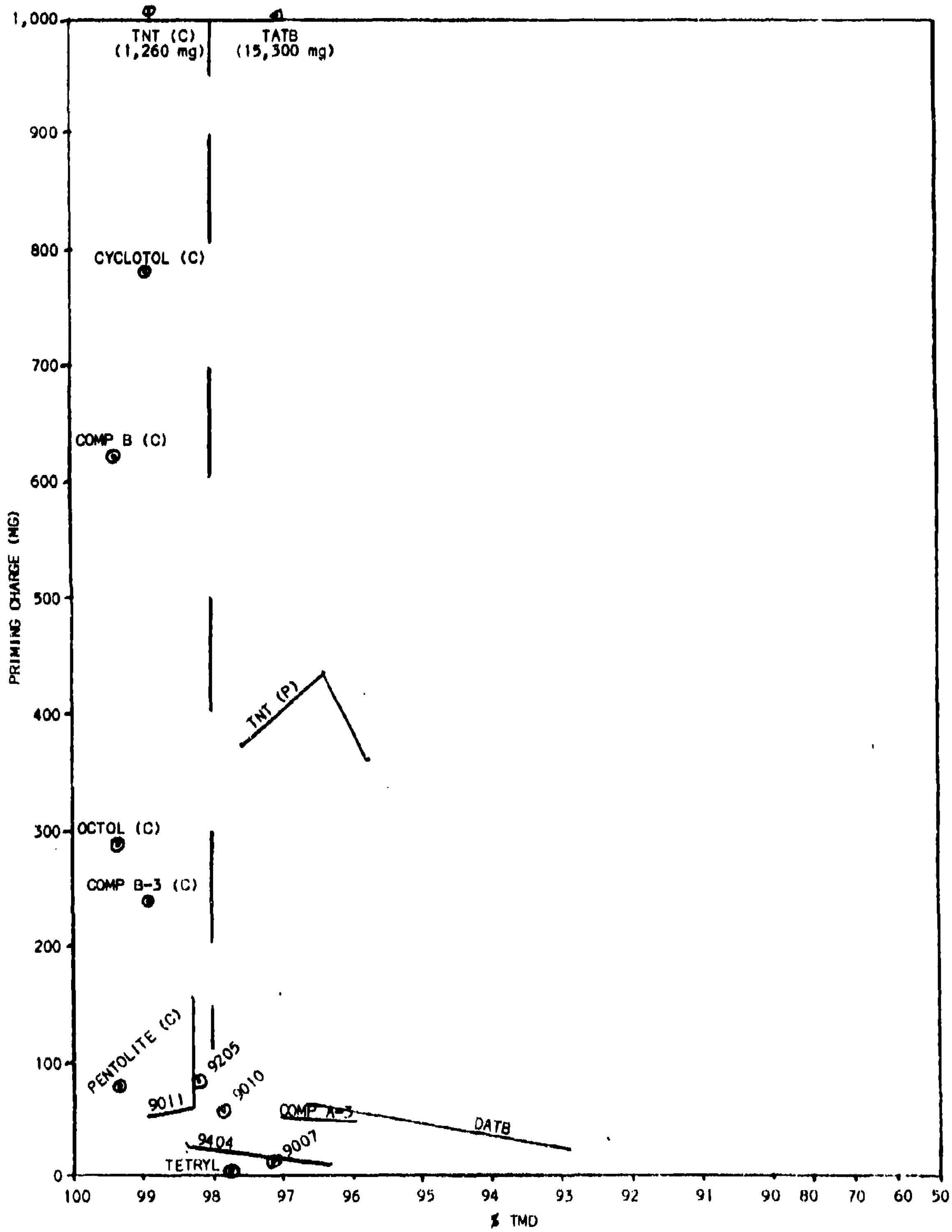


FIGURE 11. LANL MINIMUM PRIMING CHARGE TEST

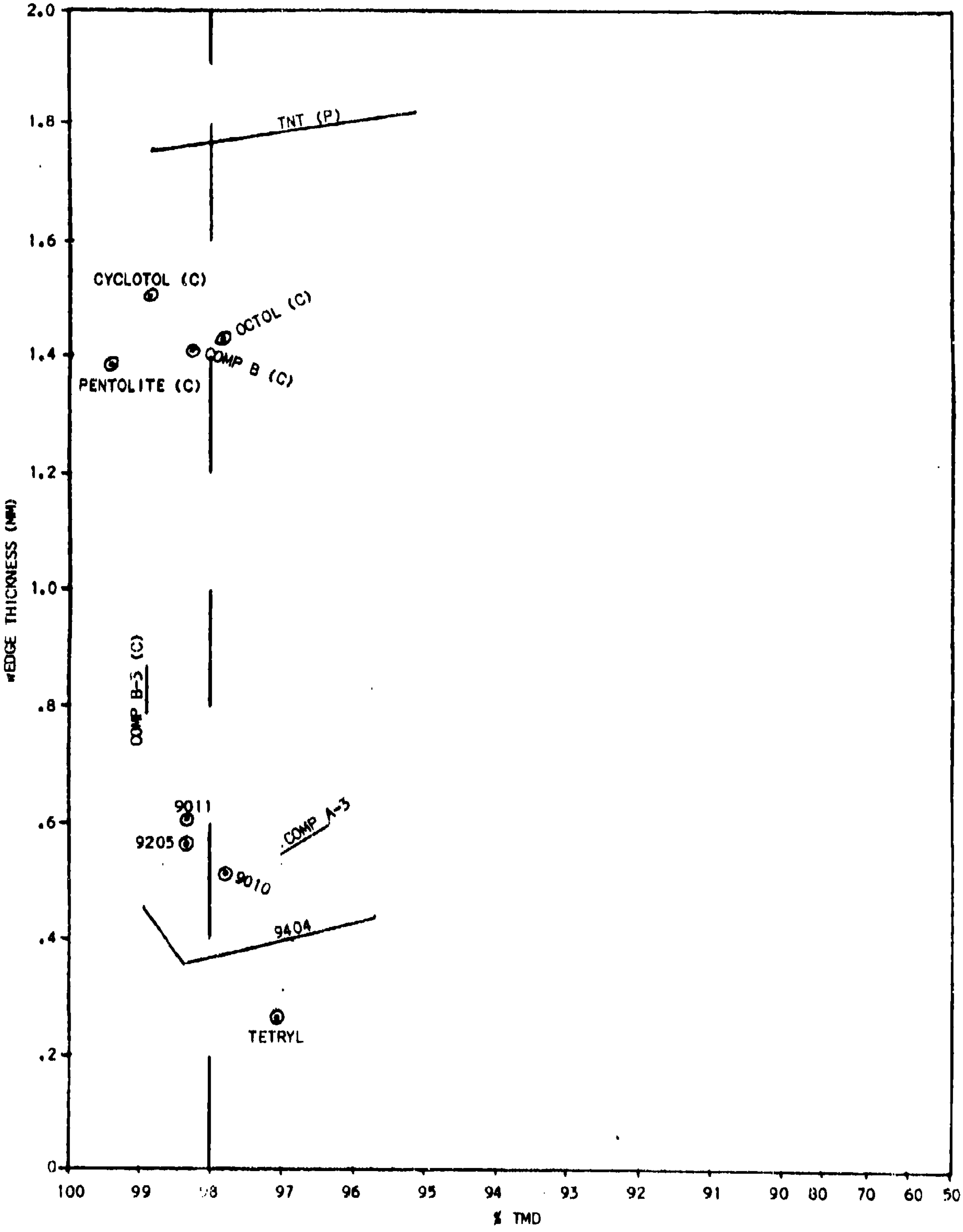


FIGURE 12. LANL WEDGE TEST

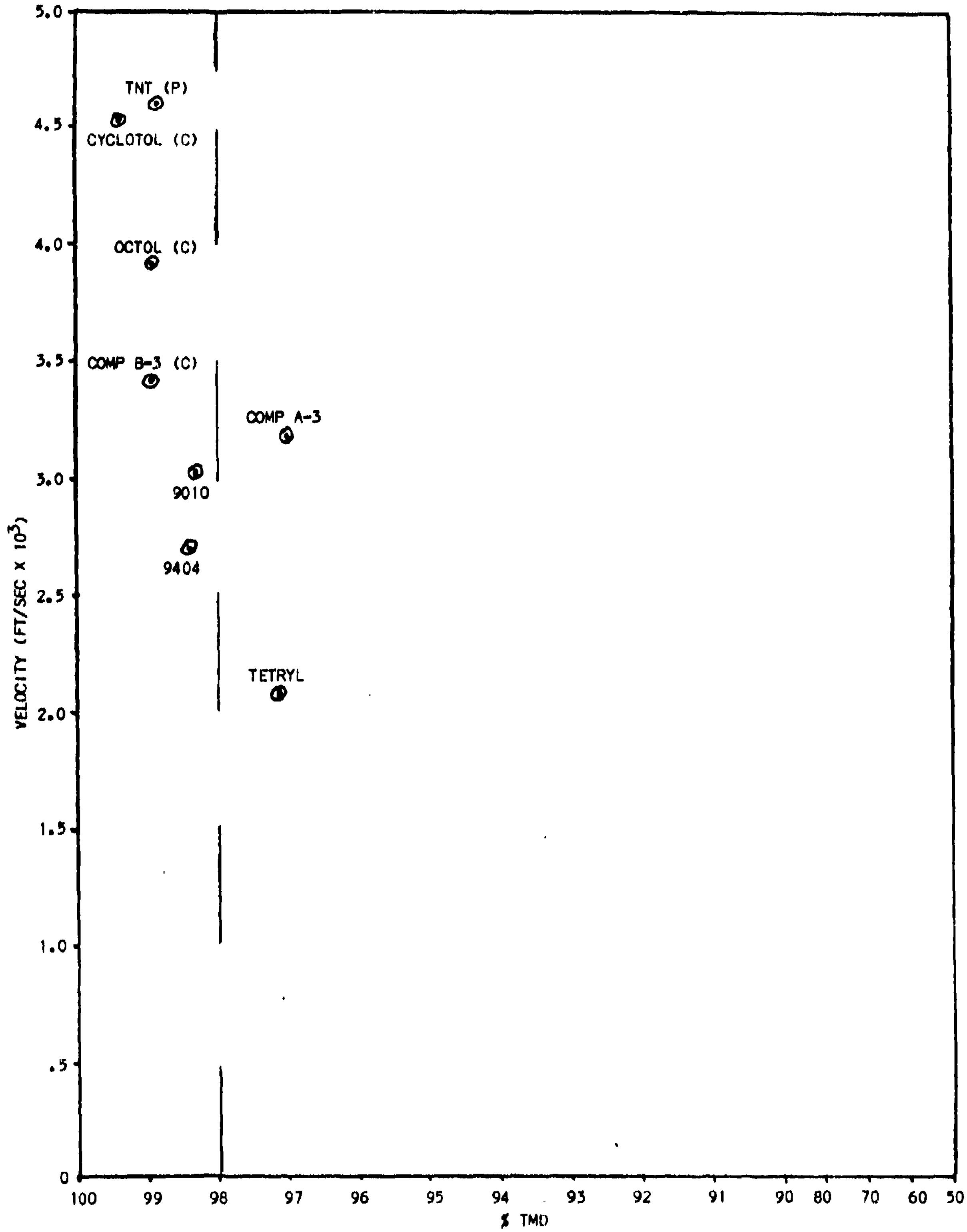


FIGURE 13. LANL RIFLE BULLET TEST

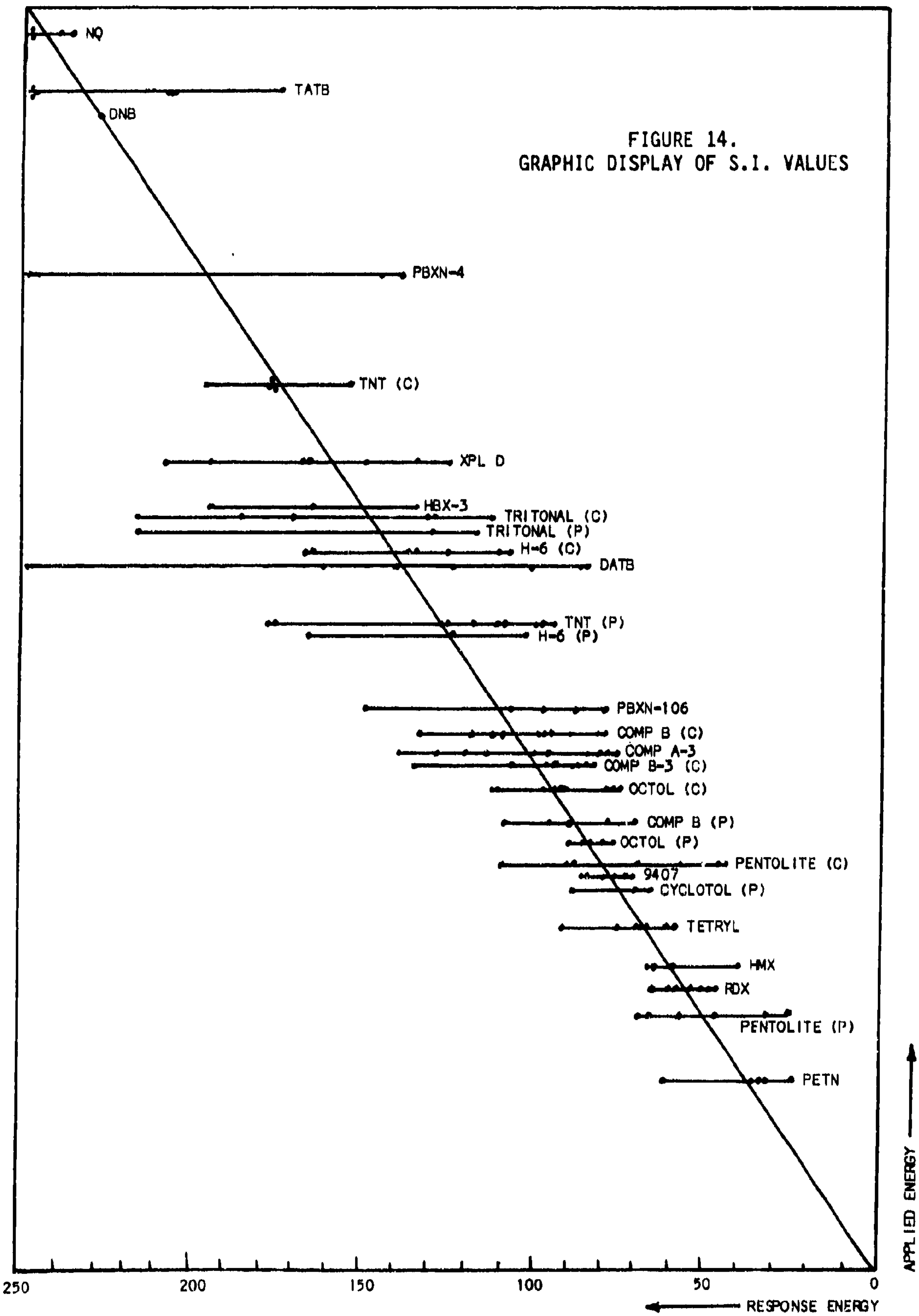


FIGURE 14.
GRAPHIC DISPLAY OF S.I. VALUES

APPENDIX

DEVELOPMENT OF THE CONVERSION EQUATIONS

A graph was constructed consisting of an ordinate arbitrarily representing increasing levels of energy required for an explosive response, versus an abscissa with increasing levels of energy applied to test samples. Separate abscissa scales were made for each test method, with its own particular unit of measure, arranged to conform to the definition of the abscissa. For example, gap test values decreasing away from the origin, and impact values increasing. A thin, horizontal strip of cardboard was made for each explosive, scaled to fit the length of the abscissa. Respresentative (98% TMD for solids) test data were marked on the strip in color-coded identifying symbols from the appropriate test method abscissa scale. Each strip was moved up the ordinate scale, and located in accordance with the apparent relative response energies denoted by each test method result. It became apparent that many of the test methods' results were forming similar patterns. By adjusting the spacing between the strips, each of five test methods' results could be connected by straight lines, implying good correlation between them. By assigning values from 0 to 250 to the ordinate scale, the graph provided coordinates to develop linear equations to convert the units of each of those correlating test methods to ordinate scale values, the Susceptibility Index (S.I.). An average S.I. value was then calculated for each explosive, and linear regression analysis was performed to refine the conversion equations until optimum correlation was achieved between those test methods. This established the significance of the S.I. values.

Unfortunately, there was no fixed format for producing conversion equations for the remaining test methods, so a "cut and fit" approach was used to best equate the range of a test's results to an appropriate S.I. range. For example, drop hammer impact heights provided better translating media when treated as measures of impact velocity ($\sqrt{\text{height}}$), rather than potential energies (height).

Since they were derived solely on the basis of personal judgment, these last equations may not be the most appropriate, and could possibly be improved on.

TABLE A.I. NOMINAL COMPOSITIONS OF EXPLOSIVES

Designation	Ratio	Ingredients
AN/TNT/AL	40/40/20	AN/TNT/AL
CH-6	97.5/1.5/.5/.5	RDX/CALCIUM STEARATE/ GRAPHITE/POLYISOBUTYLENE
COMP A-3	91/9	RDX/WAX
COMP A-5	98.5/1.5	RDX/STEARIC ACID
COMP B	63/36/1	RDX/TNT/WAX
COMP B-3	60/40	RDX/TNT
COMP C-4	91/9	RDX/PLASTICIZER
CYCLOTOL	75/25	RDX/TNT
DESTEX	75/19/5/2/.07	TNT/AL/WAX/CARBON/LECITHIN
DETASHEET	60/40	PETN/BINDER
H-6	45/30/20/5/.5	RDX/TNT/AL/WAX/CaCl
HBX-1	40/38/17/5/.5	RDX/TNT/AL/WAX/CaCl
HBX-3	31/29/35/5/.5	RDX/TNT/AL/WAX/CaCl
MINOL II	40/40/20	AN/TNT/AL
OCTOL	75/25	HMX/TNT
PBXN-1	68/20/12	RDX/AL/NYLON
PBXN-2	95/5	HMX/NYLON
PBXN-3	86/14	RDX/NYLON
PBXN-4	94/6	DATB/NYLON
PBXN-5	95/5	HMX/VITON
PBXN-6	95/5	RDX/VITON
PBXN-101	82/18	HMX/BINDER
PBXN-102	59/23/18	HMX/AL/BINDER
PBXN-103	40/27/27/6	AP/AL/PLASTICIZER/NC
PBXN-104	70/30	HMX/BINDER
PBXN-105	50/26/17/7	AP/AL/BINDER/RDX
PBXN-106	75/25	RDX/BINDER
PENTOLITE	50/50	PETN/TNT
PICRATOL	52/48	EXPLOSIVE D/TNT
TRITONAL	80/20	TNT/AL
9007	90/9.1/.5/.4	RDX/POLYSTYRENE/DI-PHTHALATE/ ROSIN
9010	90/10	RDX/KEL F
9011	90/10	HMX/ESTANE
9205	92/6/2	RDX/POLYSTYRENE/DI-PHTHALATE
9404	94/3/3	HMX/NC/TRIPHOSPHATE
9407	94/6	RDX/EXON
9501	95/2.5/1.25/1.25	HMX/ESTANE/BDNPA/BDNPF

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